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Bands observed in the Spectra of Sun-spots at Stonyhurst Observatory. By the Rev. A. Cortie, S.J.

(*Communicated by the Rev. S. J. Perry.*)

There are three kinds of bands which have been observed in the spectra of Sun-spots. The first, which is a certain fuzzy appearance surrounding the widened portions of the dark lines, has been very frequently seen, and is only a particular phase of the widening of the line. The second is an intensifying of the general absorption due to a Sun-spot in particular parts of the spectrum. The third is the appearance of real bands in the selective absorption due to a spot. The present paper contains some observations of each of these kinds of bands.

With regard to the hazy appearance or fuzziness surrounding a widened line, it is usually and most easily observed on the D lines, although not peculiar to them. In a spot in the S. F. quadrant of the Sun observed on November 15, 1883, the widening of all the lines, instead of a dark and distinct thickening of the same, presented the appearance of a penumbral shade at either side of the dark central line. But this haziness has been most markedly attached to the D lines on several occasions. Thus on September 29, 1884, and on January 14, 1886, these two lines were not only widened and fuzzy, but were also reversed in one portion of their length. Sometimes the haze exists surrounding the lines, while the lines themselves are not widened, as on October 2 and 3 of the present year in a small spot. In the part of the spectrum between D and C, Ångström gives a line as due to *Na* at 6160·23 a little more refrangible than a strong *Ca* line at 6160·40. This *Na* line is drawn as double in the maps of Fievez and Piazzi Smyth, and with good definition, and using a dispersion of twelve prisms, it has been usually so seen. This double is always remarkably widened in the spectra of spots, and, moreover, the widening is of the nature of the fuzzy band seen at times in connection with the D lines. If a moderate dispersion of six prisms be used, it appears as if the *Ca* line adjoining this faint double was considerably widened and displaced towards the violet. But on using a great dispersion the widening is seen to be principally due to these faint *Na* lines, although the thick *Ca* line is usually also affected. On June 25, 1885, and on January 14, 1886, the widened *Ca* line was seen running through the haze due to these *Na* lines. In the small spot of October 2 of the present year, the band due to these lines was at least one-tenth mètre in breadth. Finally it may be mentioned in connection with the D lines, that when the widening on the two sides is unequal, the balance is almost invariably in favour of the violet or more refrangible side of the lines.

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The second kind of band is due to the intensifying of the general absorption in particular parts of the spectrum of Sun-spots. This phenomenon has only been observed on four occasions during the course of as many years of observation. On May 11, 1884, the general absorption of a large spot N F. had a blurred appearance in the red end, and besides was so dark that it almost masked the selective absorption, rendering it very difficult of observation. The same appearance was seen on May 18 of the same year in a black spot S P. Again, on June 25, 1885, the lines about 6172·5 were masked by this blurring effect; and, finally, on February 6, 1886, the relative darkness of the general absorption in the red end was much more intense than in the rest of the spectrum. This last observation was made between 2 and 3 P.M. in a hazy sky. In the Greenwich observations of the great Sun-spot of November 19, 1882, it is noted that "the general absorption was not uniform; here and there there were ill-defined patches, noticeably darker than the rest of the spectrum." Again, although Prof. Young, using a Rowland grating attached to a 23-inch equatorial, has succeeded in resolving even the band of continuous shade, due to a Sun-spot, into a series of fine dark lines with bright spaces (*Amer. Jour. Science*, vol. xxvi. November 1883), yet he remarks that "in the red, even with the highest dispersion, and under the most favourable circumstances of vision, the spot-spectrum appears simply as a continuous shade, crossed here and there by widened and darkened lines."

The last of the three kinds, into which we have divided this phenomenon of spot-bands, is perhaps the most important of all, because of its connection with the selective absorption of Sun-spots. The first recorded observations of these bands are those of Professor Young (*Nature*, December 12, 1872). With regard to their interpretation he states that "they would seem to point to such a reduction of temperature over the spot-nucleus as permits the formation of gaseous compounds by elements elsewhere dissociated." In the Greenwich Spectroscopic and Photographic Results for the years 1880–83 many observations of similar bands are recorded in the portion of the spectrum from D to F. At Stonyhurst the spot-spectrum is observed from D to B. The spectroscope employed is an automatic instrument by Browning, and the dispersion generally used is one of twelve prisms of 60°. Perhaps the region richest in the various phenomena of the spectra of Sun-spots in this part of the spectrum is that included between λ 6370·0 and C. Nine of the lines have coincident bright lines in the chromospheric spectrum as mapped by Young, and there are four dark basic lines. It is in this portion that the spot-bands have been most frequently seen, and two of them have been selected for particular attention and study. The bands were first noticed on February 28, 1885, especially a broad one lying between the lines λ 6438·35 and 6449·29, and they have been seen on eight

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subsequent occasions. The number of bands so far reckoned is nine. Of these the two more particularly studied are situated the one near λ 6380·0 and the other at λ 6383, the positions being fixed by accompanying lines, and being most probably correct to within one-tenth mètre. On May 26 of the present year these two bands were most distinct in a spot of regular outline. The first adjoined the line λ 6379·99 on its less refrangible side. The second had no line at its edges but was diffused in appearance, although its tint was somewhat intensified towards the red end. The general appearance of these bands resembled a fluted spectrum, and some very faint lines could be traced from them into the ordinary spectrum. These two bands were again examined most carefully on July 2nd and 4th of the present year in magnificent definition. The general absorption given by the spot was one with well-defined edges. On the former of these dates the spot-band at λ 6379·99 was joined on to the line as observed on May 26. But on the 4th, when the general absorption was less intense, it no longer adjoined the line, but was clearly separated from it. Moreover, its appearance had altered, for it seemed to be formed by two or three lines very greatly widened. The companion band also seemed to be composed of three lines similarly affected. But these bands or groups of lines were due to the spot alone, for no trace of them could be detected when the spot was removed from the slit, and they stood out most clearly and distinctly in the darkest part of the umbra. On the 7th, when the spot had approached the limb, none of the bands were so distinct as formerly, although the definition was equally good. Yet they were visible in the spot, and nowhere else. In the small spot of October 2nd and 3rd no bands at all could be detected in the region between λ 6379·99 and C. On the 3rd, however, the lines at 6242·6 (A°) and 6305·0 (Fievez) had a banded appearance on their more refrangible side, possibly due to a displacement in that direction. It may be noted, however, that this line 6305·0 corresponds to a line in Young's diagram (*loc. cit.*) marked at K 796·2, which is depicted as enormously widened.

Finally, with regard to the two bands selected as typical of this third class, this must be remarked, that they occur in a portion of the spectrum in which Ångström marks no line, and in which the very great dispersion employed by Fievez and Piazzi Smyth gave in the first case two, and in the second three faint lines, about the position of the second band. Coincident with the first band there is absolutely no dark line mapped, which is true also for the bands between λ 6438·35 and λ 6449·29. This, coupled with the fact that they appear only in Sun-spots, and there are most intense in the umbra, shows them to belong exclusively to Sun-spot spectra. They are a phenomenon altogether distinct from the ordinary widened, or darkened, or obliterated line of such spectra. From fifteen to twenty such bands are recorded in the Greenwich observations.

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nine have been seen at Stonyhurst, and always in the same positions. Even should higher dispersion resolve them into lines, such clusters of greatly widened lines occurring at certain definite positions in the spectra of some Sun-spots is a remarkable phenomenon well deserving the closest attention.

Note on Photographs of Stars in Cygnus taken in August 1886.

By Isaac Roberts.

The negatives which I now exhibit were taken with my 20-inch Reflector on the nights of August 17, 23, 24, and 25 this year, and they represent parts of the constellation *Cygnus*, corresponding with those photographed by MM. Henry with their 13-inch refractor in June and August 1885, copies of which have been presented to the Society as well as to some of the Fellows.

The celestial position of the centre of each plate is as follows:

			h m		° ′
No.	1	R.A.	21 2	Decl.	38 12
	3	,,	19 45	,,	35 30
	4	,,	19 55	,,	37 45
	5	,,	20 4	,,	35 30

The enlargements have been made to the scale corresponding with that adopted by MM. Henry so as to facilitate comparisons between them. The time of exposure, namely, 60 minutes, is common to all the photographs.

If we compare these plates with those by MM. Henry there are striking differences observable in the sharpness of the margins of the star discs, in the density of the images, and in the number of stars photographed in 60 minutes by the two instruments respectively.

In the Henry plates the margins of the stars are remarkably sharp and clearly defined. The brightness or density of the images also, whether the stars are of the second or of the fifteenth magnitude, is equal in all without perceptible gradation. The reflector, on the contrary, shows the margins somewhat undefined, and the stars of the first to the third magnitude show prominently diffraction effects around them. Not less noticeable is the gradation of the light of the stars between the brightest and the faintest shown on the plates; the gradations are such that the stars are ultimately lost in the colour of the background or film, and to define their magnitudes will severely tax the powers of classification.

In drawing inferences from the relative numbers of the stars